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# ADVANCED DISTRIBUTED SIMULATION TECHNOLOGY ADVANCED ROTARY WING AIRCRAFT

## SYSTEM/SEGMENT SPECIFICATION VOLUME III of V VISUAL SYSTEM MODULE



Loral Systems Company
12151-A Research Parkway
Orlando, FL 32826-3283



31 March 1994

Contract No. N61339-91-D-0001
ARWA - Delivery Order No. 0048
CDRL A00E

Prepared for:

Simulation Training and Instrumentation Command
Naval Air Warfare Center
Training Systems Division
12350 Research Parkway
Orlando, FL 32826-3224



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13. ABSTRACT (Maximum 200 words)
The ADST ARWA System/Segment Specification establishes the functional requirements for the Advanced Rotary Wing Aircraft (ARWA) Simulator System (SS). Volume III describes the requirements for the Visual System Module (VSM). The VSM component provides functions of global bus communication interfaces to the other segments, visual system controller, display device control, head tracker function control, and data base storage control.

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# 1. SCOPE

1.1. Identification. This Module Specification volume establishes the requirements for the Visual Module of the Advanced Rotary Wing Aircraft (ARWA) device. This volume is one of three volumes of a System Specification defining an Advanced Rotary Wing Aircraft Simulator System (ARWA SS) for tactical combined forces aircrew simulation devices. Volume I of this specification contains system level requirements which include those pertaining to system structure, communication architecture, network interface performance, system diagnostic and test, programming language applicability, adaptability and expandability.

1.2. Purpose. This Module Specification volume defines the requirements of the Visual Module for one ARWA device. This specification contains descriptions of the functions performed within the module, communication interface requirements, module performance requirements, module diagnostic and test requirements and expandability and adaptability requirements as applicable to the Visual Module.

1.3. Introduction. The principal purpose of the Visual Module is to simulate out-the-window and sensor imagery and to display this imagery to the crew members of an ARWA device. In addition, this module provides for the ARWA device the information pertaining to relationship between visual data base models and geographic positions. In this specification the role of the Visual Module is partitioned into the following functional areas:

a) ARWA Global Bus Interface Function which provides the physical and logical connection of the Visual Module with the other modules of the ARWA device.

b) Visual System Controller Function which coordinates the operations of all the other functions in the module.

c) Image Generation Function which produces the video imagery in response to the controls of the Visual System Controller.

d) Display Device Function which produces the visible displayed images from the video inputs.

e) Intervisibility Function which provides the interrelational information of the data base models and geographic positions.

f) Head Tracker Function which reports the instantaneous position and orientation of the helmets of the crew members within the cockpit.

f) Data Base Storage Function which provides immediate access to the visual data base.

This specification establishes the functional requirements for each of these functions and their interfaces.

# 2. APPLICABLE DOCUMENTS

2.1. Government Documents. The government documents which are applicable to the entire ARWA SS are listed in Volume I of this specification. The following additional government documents are applicable to the Visual Module: None.

2.2. Non-Government Documents. The non-government documents which are applicable to the entire ARWA SS are listed in Volume I of this specification. The following additional non-government documents are applicable to the Visual Module:

ADST Step One Technical Report (Draft), Boeing Defense and Space Group, Huntsville, AL, 7 August 1991

AH-64A APACHE AIRCRAFT COCKPIT CONFIGURATION TECHNICAL REPORT (Draft), Version 1.2, DSC Corporation, Alexandria, VA, 2 August 1991

AH-64C/D APACHE AIRCRAFT COCKPIT CONFIGURATION TECHNICAL REPORT (Draft), Version 1.0, DSC Corporation, Alexandria, VA, 2 August 1991

DATA TO SUPPORT SIMULATION OF RWA VISUAL SYSTEMS, Version 1.1, DSC Corporation, Alexandria, VA, 2 August 1991

PRELIMINARY DATA OF MAGNIFICATIONS OF DISPLAYED RWA SENSOR IMAGERY, DSC Corporation, Alexandria, VA, 9 August 1991

3. REQUIREMENTS

3.1. Module Definition.

3.1.1. Missions. The mission of the Visual Module is to provide imagery of sufficient fidelity to support the mission requirements as described in Paragraph 3.1.1 of Volume I of this specification.

3.1.2. Threat. Not applicable.

3.1.3. Module Modes and States. The Visual Module shall operate within the various modes and states as defined in Volume I, Paragraph 3.1.3. The Visual Module shall also function in accordance with the mode and state transition requirements define in Volume I, Paragraph 3.1.3, and diagrammed in the following figures: Figures 3.1.3.3-1 and 3.1.3.3-2.

3.1.3.1 Module Mode. This mode has two states: Start-up Initialization and Stand-alone.

3.1.3.1.1 Start-up Initialization. Upon power up, each component of the Visual Module, as appropriate, shall execute internally stored (read only memory (ROM)) boot-programs to initialize communication paths within the Visual Module and between the Visual Module and the ARWA Network (FDDI Network). The Visual System Controller (VSC) Function shall then direct the loading of the various initialization and diagnostic programs: to initialize each Visual Module component to a state in which to receive simulation specific application programs; to perform morning readiness diagnostics; and to report pass/fail availability of the Visual Module (to the Simulation Manager via the ARWA Network).

Based upon commands from the Simulation Master via the ARWA Network (FDDI), the Visual Module either transitions to System Mode or enters the stand-alone state of Module Mode.

3.1.3.1.2 Stand-Alone State. The initial transition to stand-alone mode is accompanied by the retrieval, loading and execution of the VSC Function program to control the stand-alone state. In this state the Visual Module shall respond to controls and data which are received via the ARWA Network (FDDI). These controls and data can originate with the Simulation Manager or with any user station on the network. The functional requirements of this state are described with the VSC Function requirements.

3.1.3.2 System Mode. The initial transition to this mode is accompanied by the retrieval, loading and execution of any programs required to establish the Visual Module and ARWA Global bus interface. In this mode the Visual Module awaits mode transition commands on the ARWA Global bus. From the System Mode, the Visual Module can transition to the Remote Controlled Diagnostic Mode, the Simulation Mode or the Shut Down Mode.

3.1.3.3 Simulation Mode. Figure 3.1.3.3-1 depicts the simulation mode. Figure 3.1.3.3-2 depicts the state transitions of this mode.

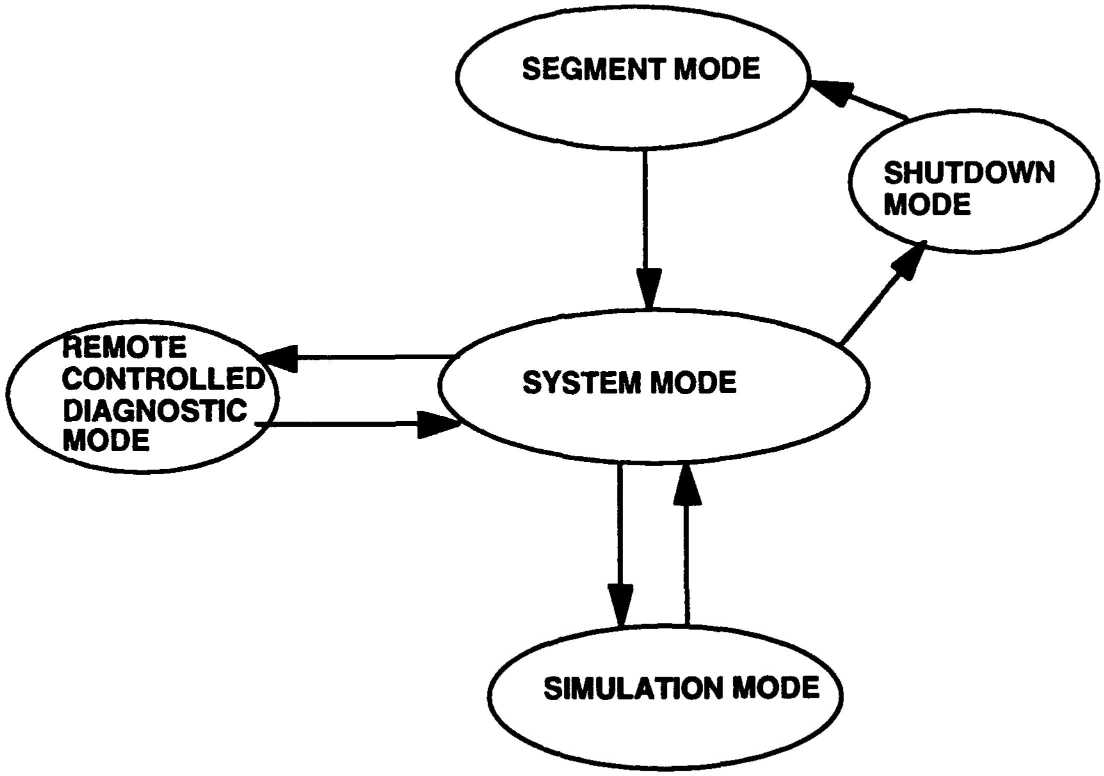


Figure 3.1.3.3.-1 Simulation Mode

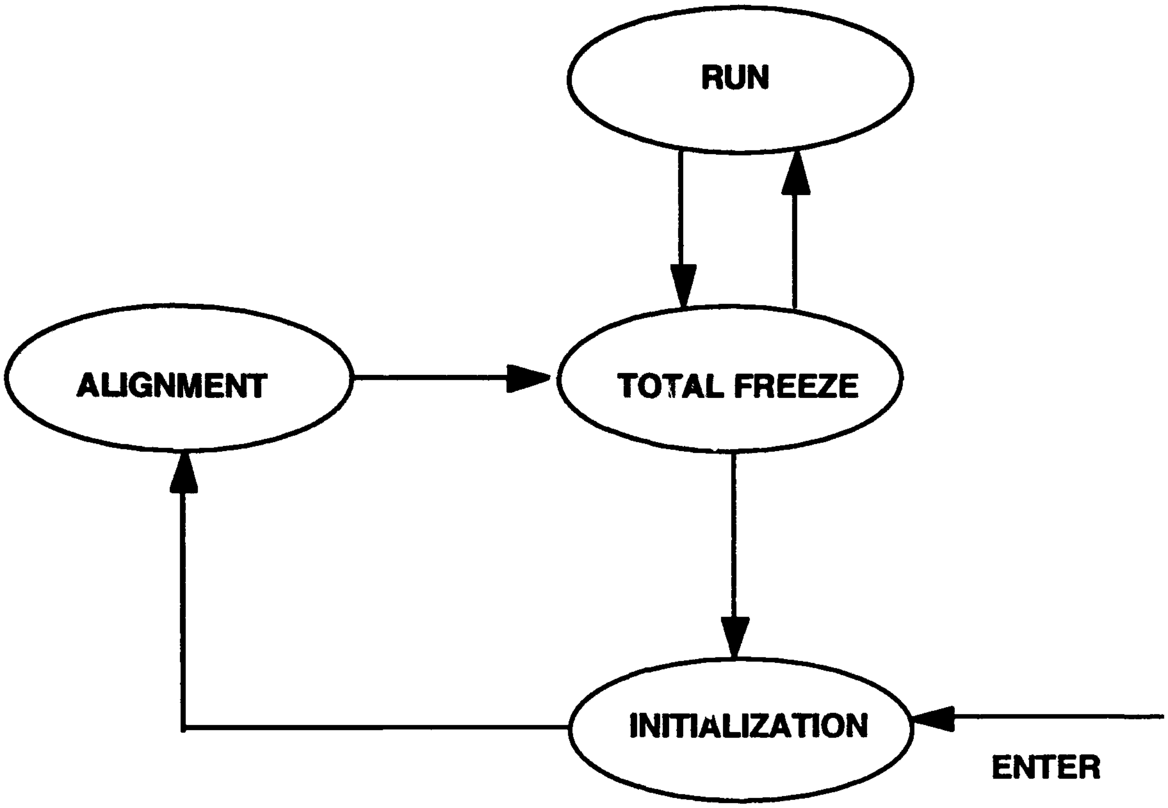


Figure 3.1.3.3.-2 States of the Simulation Mode

3.1.3.3.1 Initialization State. Upon transition to Simulation Mode, the Visual Module is in this state. When entering this state from System Mode, the Visual Module shall retrieve (over FDDI from the software (SW) Maintenance station), load and execute the simulation programs for the various Visual Module components. When all components are executing their programs, the module is ready to respond to a state transition command to enter the Alignment State or return to the System Mode.

3.1.3.3.2 Alignment State. Upon entry into this state, the Visual Module shall retrieve the relevant data definition files from the Software and Data Base Maintenance stations. If the appropriate data base files are not resident in the Visual Module data base storage devices (the wrong or incorrect version of the data base is loaded), the Visual System Controller Function shall coordinate the loading of the appropriate data bases over the Intervisibility Servers (FDDI) Network. The VSC shall then proceed to initialize the other Visual Module components as appropriate to the conditions specified in the data definition files. These conditions shall include the terrain data base position of the ownship and the initial modes of the sensors; and therefore, in this state, the terrain data appropriate for the position of the ownship can be retrieved and loaded into the memories of the image generator.

When all data loading and other Visual Module initialization is completed, a completion message is communicated over the ARWA Global bus and the Visual Module stand ready for a transition command to the Total Freeze State.

3.1.3.3.3 Total Freeze State. In this state the components of this Visual Module are executing the simulation programs; however, no internal parameters, as ownship position, nor other aspects of image content, are being updated.

3.1.3.3.4 Run State. In this state the Visual Module is producing images, as well as Intervisibility Function results, based on control parameters received via the ARWA Global bus and from the Helmet Tracker Function.

3.1.3.4 Remote Controlled Diagnostic Mode. The Visual Module shall support this mode by responding as appropriate to the two self-test commands which are received via the ARWA Global bus. The Visual Module's response to these two self-tests is coordinated by the VSC Function (Refer to the Visual System Diagnostics paragraph of the VSC Function Requirements for a description of the processing of the two-self tests).

3.1.3.5 Shut Down Mode. The Visual Module has no required actions in this mode. When the command to transition into Shut Down Mode (from System Mode) is received, the Visual Module shall transition into Module Mode.

3.1.4. Module Functions. A top-level diagram of the functions composing this module with their interrelationships and their external interfaces is given in Figure 3.1.4-1.

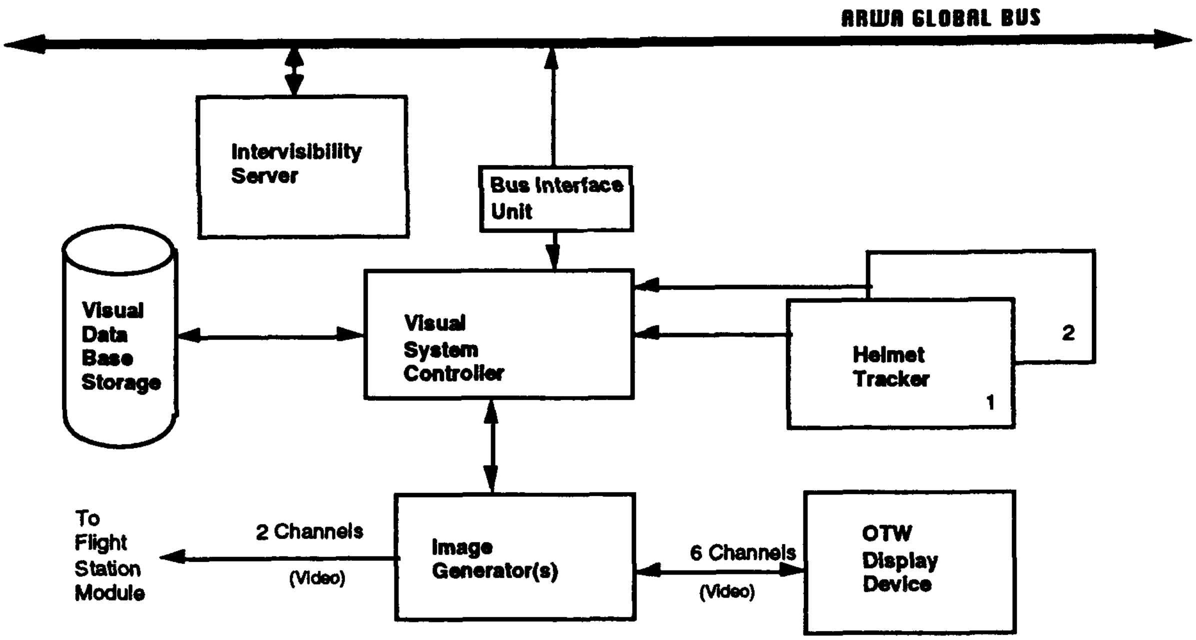


Figure 3.1.4-1 Visual Module Block Diagram

3.1.4.1. ARWA Global Bus Interface Function.

3.1.4.1.1. Purpose. This interface provides the physical and logical linkage of the Visual Module and the remainder of the ARWA device. The role of this interface in the device is fully described in Paragraph 3.1.7 of Volume I of this specification. For the Visual Module this interface function captures commands and data on the ARWA Global Bus which are addressed to the Visual Module and makes these data available to the functions of the Visual Module in a format which these functions can recognize (e.g., ARWA Global Bus (ModSim) headers and trailers are removed).

3.1.4.1.2. Physical Characteristics. The physical realization of the function is the Bus Interface Unit (BIU) which is fully described in Paragraph 3.1.7 of Volume I of this specification.

3.1.4.1.3. Performance Characteristics. The functional requirements of the BIU are specified in Paragraph 3.1.7 of Volume I of this specification.

3.1.4.2. Visual System Controller Function.

3.1.4.2.1. Purpose. The Visual System Controller (VSC) function provides the (logical) interface between this module and the ARWA Global Bus (via the BIU) and the ARWA Network Bus. Thus, this function controls the modes and states of the module, coordinates module diagnostics, provides start-up and initialization service to all components of this module, controls the visual system processing load and controls the image generation function by providing the commands and appropriate model data necessary to product the video images as indicated by the controls via the ARWA Global bus.

The VSC Function also includes the control of the Intervisibility Server Function.

When the Visual Module is not integrated with ARWA Global Bus, the VSC Function provides a resource to generate ARWA Global Bus commands and data to exercise most of the operations of this module. This function shall be able to respond to commands and data received via the ARWA Network from any user workstation on the network.

3.1.4.2.2. Physical Characteristics. The principal functionality of the VSC is implemented in applications programs which can reside in a stand-alone computational system or on one or more microprocessor cards residing with other physical component of the system (e.g., in the image generator or shared with the BIU card). The VSC shall support the intermodular interfaces of the Visual System Module as described in Section 3.7.

3.1.4.2.3. Performance Characteristics.

3.1.4.2.3.1. Start-up Initialization. As part of power-up and after shut-down, this function shall retrieve an initialization load which shall run diagnostic tests necessary to determine the readiness of all visual system components. If all components are ready, a ready signal shall be generated; otherwise, a failure report shall be generated indicating which components are not available. During this initialization phase, this function shall establish communication with the ARWA Global Bus (via the BIU) if Module Stand-along operations are not desired.

3.1.4.2.3.2. Simulation Initialization. As commanded over the ARWA-Global bus, the VSC Function shall retrieve, load and start executing the appropriate simulation program load which is stored in the Software Maintenance Station. This simulation program shall establish its own communications with the ARWA Global Bus (via the BIU). The simulation program shall retrieve over the ARWA Network mission specification and initial condition files and shall provide the initial code and data loading based on the contents of these mission and initial conditions. Upon completion of this initialization and data loading process, the visual module is ready for the simulation mission. The VSC Function shall communicate mission readiness over the ARWA Global Bus.

3.1.4.2.3.3. Visual System Diagnostics. The VSC Function shall provide three levels of diagnostic support: Start-up readiness testing as described in Start-up Initialization; fault isolation diagnostics for the hardware components comprising the visual module; and remote diagnostics which consist of the two capabilities described below.

For remote diagnostics, the VSC Function shall coordinate the echo-back test in which the contents of the echo-back test request are returned over the ARWA Global Bus. The VSC shall also support the equipment test which requires that each piece of equipment in the visual module be polled for readiness and a collective pass/fail status message be returned over the ARWA Global Bus be returned indicating the status of each of the pieces of equipment.

Fault isolation diagnostics shall be controlled in stand-alone state of Module Mode by means of commands received via the ARWA Network.

3.1.4.2.3.4. System Freeze. The VSC Function shall support the total freeze state ( which is entered after simulation initialization is complete). In this state all visual module updates of positions, attitudes, animations, and other time variable parameters cease. It shall be possible to select subsets of these variable parameters for partial freezes in states other than total freeze (e.g., the freezing of positional updates of the moving models and ownship but not the attitude updates of the head tracker). Subsets of the time variable parameters shall be included in the partial freezes.

3.1.4.2.3.5. Security Shutdown. The VSC Function shall support the security shutdown requirements by taking no action when in the Security Shutdown Mode. Upon being commanded to enter this mode, the VSC Function shall immediately enter into Module Mode and commence Start-up Initialization

3.1.4.2.3.6. Dynamic Data Interface Control. There are two sources of external dynamic data entering the VSC Function: The data from the ARWA Global Bus via the BIU and the data from the head tracking function.

The VSC shall provide the interface handlers for the BIU and the drivers for Head Tracker.

All dynamic position and attitude data received from either of these two interfaces shall be both converted into coordinate systems required by the Visual Module and shall be extrapolated to account for both lags introduced by system and network transmission and by the asynchronous operation of the different clocks within the ARWA device. Conversion to a visual system data base coordinate system shall be performed, when required, due to the use of spherical (lat, long, altitude above Earth center or above mean sea level) or other coordinate system data representations exterior to the Visual Module.

3.1.4.2.3.7. Stand-Alone Operations. The VSC Function shall support the stand-alone state of the Module mode with the capability to generate commands and data which emulate: a) those received over the ARWA Global Bus during Simulation Mode but in the format which the VSC receives from the BIU; and b) those received from the head tracker function.

During stand-alone operations, the VSC Function shall respond to commands and data received via the ARWA Network (FDDI). These commands and data can be generated at any user workstation on the network, including the Simulation Manager.

In this state, the BIU is not connected to the ARWA Global Bus but the VSC shall received the emulated data and commands as though this connection were present. In the stand-alone state, the VSC Function shall be able to generate the post-BIU ARWA Global Commands and data necessary to test and demonstrate all aspects of the Visual Module's operations including: the contents of mission parameter files, all state and mode transitions commands, all sensor controls, all ownship and moving models controls, all diagnostic test commands and requests for Intervisibility Function resources.

In this stand-alone state, an operator shall be able to place the ownship and some moving models in the gaming area with any positions and attitudes and with continuous updating of these parameters. The operator shall also be able to specify head position and attitude.

In this state, the VSC Function shall coordinate fault isolation diagnostics via controls received on the FDDI network.

3.1.4.2.3.8. Image Generation Control. The VSC Function shall generate and transfer to one or more image generators full instructions for the generation of the two sensor images.

The generation of instructions and their transfer shall be accomplished so that the total transport delay from receipt of the position and attitude data by the VSC to the start of display of the image incorporating these data does not add more than 10% to the allowable transport delays specified by the Image Generation Function.

Similarly, the time to respond to changes of sensor mode, field of view (FOV) and time-of-day (TOD) shall not be more than 10% of that specified by the Image Generation function. This time includes any needed reloading of color and/or sensor intensity data tables.

The image generation controls shall include:

a) The update of the position, attitude and geometry of the two sensor and the out-the-window (OTW) image generation windows.

b) The indication the appropriate models for potential inclusion into the sensor and OTW images along with the controls for each model's visibility and illumination as appropriate for the TOD, visibility range and environmental conditions as fog, clouds, smoke and, for moving ground vehicles as required by shadow occultation of models determined to be in the shadow of some terrain model as determined by the Intervisibility Function; and as required by the image generation function model prioritization control (which may require the services of the Intervisibility Function).

c) The positions and attitudes of all potentially visible moving models along with appropriate articulated part data, including ownship rotor control.

d) Activation and control of the animation of sequences representing weapons and other effects.

e) Activation and position control of the display of environmental models.

f) The level-of-detail transitioning into view of models introduced into the scene at such a distance that their abrupt appearance would create distracting anomalies.

3.1.4.2.3.9. Visual Data Base Control. The VSC Function shall support the dynamic loading of the image generator memories with terrain, moving and environmental models as these models become required for the generated images (Refer to the Scene Models paragraph of the Image Generation Function specification). When data base models are required, they are retrieved from the visual system data base mass storage device. The time constraints on the retrieval and loading of data models are discussed, when appropriate, with each model category.

The VSC Function also supports the data model loading required during the Simulation Initialization state proscribed by the mission and initial parameters. In this state, all models of certain types may be loaded in order to enable rapid activation during the Run state.

3.1.4.2.3.9.1. Terrain Data Base Retrieval. The VSC Function shall support the dynamic retrieval and image generator loading of the terrain model data within a 500 km by 500 km region. This function shall maintain a 360 degree region around the ownship to a distance sufficiently beyond the commanded visibility ranges of the OTW and sensor images to avoid visible popping into the scene of terrain models. (The maximum visibility ranges required are given in the Scene Models paragraph of the Image Generator Function). This dynamic retrieval and loading must be sustainable for ownship speeds not less than 300 nautical miles per hour.

The VSC Function shall support the retrieval and loading of different LOD of terrain models if this is required by the Image Generation Function.

The terrain data base retrieval process shall include the retrieval and loading of all terrain cultural features including library and/or procedural models and specific texture patterns ( if their loading is not part of simulation initialization).

3.1.4.2.3.9.2. Moving Model Data Control. The VSC Function shall retrieve and load into the image generator memories representations of those moving models which are potentially visible to any of the active fields of view (OTW or sensor FOV's). A determination shall be made as to which active moving models are potentially visible (this may require the Intervisibility Function) and, if data are required to be retrieved and loaded for display, this process shall be accomplished in a manner which avoids popping or other noticeable anomalies in the scene.

There shall be no noticeable time delays in the activation of weapon effects due to retrieval and loading processes.

3.1.4.2.3.9.3. Environmental Model Data Control. Except for time critical models (e.g., lightning), the environmental models may be retrieved and loaded based upon activation control received via the ARWA Global bus.

3.1.4.2.3.10. Intervisibility Control. The VSC Function shall provide interface capability between the Intervisibility Function of the Visual System Module and both VSC internal functions and functions exterior to the entire Visual Module. In both cases the VSC shall receive requests for the use of the Intervisibility Function. These requests will be reformatted as required and transferred to the Intervisibility Function within 5 milliseconds. Results of these requests, when made available by the Intervisibility Function, shall be returned to the ARWA Global bus or the appropriate internal function within 15 milliseconds.

The capability of the VSC Function to process these requests and results shall not restrict the throughput of the Intervisibility Function.

3.1.4.2.3.11. Visual System Load Control. The VSC Function shall monitor visual system load indicators, anticipate potential overload conditions and take corrective action to avoid overload conditions which could distract from mission performance. Any corrective action shall be performed in a gradual manner to avoid rapid changes in the visual image and in other areas of system performance. Acceptable corrective actions include:

a) The selective adjustment by scene feature type of the distance at which models switch between level-of-detail (LOD) representations.

b) The adjustment to the distances beyond which models are excluded from the generated image.

c) The adjustment to the minimum subtended solid angle for the display of polygonal faces.

d) Other non-distracting adjustments which do not affect system transport delays and field times.

There shall be parametric control over which mix of corrective actions are employed in a given mission scenario.

3.1.4.2.3.12 Spare Requirements. There shall be 50% spare capacity for VSC processing and in the VSC main memories.

3.1.4.3. Image Generation Function.

3.1.4.3.1. Purpose. This function generates the video image for the OTW scene for both crew members and the video for the two sensor images which are destined for the helmet display and/or the multi-functional displays (MFDs) in the cockpit. The images generated by this function are determined by the control data and scene model data provided by the Visual System Control Function.

3.1.4.3.2. Physical Characteristics. The requirements for this function shall be met by one or several image generation systems driven by the image generator controller.

3.1.4.3.3. Performance Characteristics.

3.1.4.3.3.1. Out-the-Window Image. The equivalent of a 135 degrees horizontal by 70 degrees vertical FOV image shall be presented from the perspective of one nominal eyepoint in the cockpit. This OTW scene shall be updated at 30 Hz and have a refresh rate of 60 Hz. The resolution required of this 135 X 70 visual image shall be equivalent to that of six (6) visual channels, each producing one-sixth of the FOV, with 640 X 480 (pixels/scanlines). The image generation function shall have at a minimum the capacity to display in this 135 X 70 FOV the equivalent of each of these six visual channels displaying 1200 visible polygons-colored, flat-shaded, textured and fully antialiased polygons (fully antialiased means at least the equivalent of eight subpixels with uniform weighting). The OTW image shall support ownship speeds not less than 300 nautical miles per hour and ownship slew rates not less than 120 degrees per second. Within this envelope the images shall be free of noticeable skipping, data voids, popping and occulting anomalies.

3.1.4.3.3.2. Sensor Images. The image generation function shall be able to produce, simultaneously with the OTW image, either one or two sensor video images. These images shall be updated at 60 Hz and have a refresh rate of 60 Hz.. For each aircraft given in

Tables 3.1.4.3-1 and 3.1.4.3-2, this function shall be able to produce any combination of different sensor mode images along with their corresponding FOVs and magnifications. Each sensor image shall have a minimum resolution equivalent to 640 X 480 (pixels/scanlines). The image generation function shall have the capacity to display in each sensor image a minimum of 1200 visible polygons-flat-shaded, textured and fully antialiased polygons (fully antialiased means at least the equivalent of eight subpixels with uniform weighting). For each sensor mode, the corresponding monochromatic image shall provide relative intensities of polygonal faces as characteristic for the sensor with the given TOD.

Table 3.1.4.3-1 AH-64D Sensor Image Characteristics

| Sensor Mode | Spectral Range (Microns) | Diagonal FOV (3:4 Aspect) | Magnification |
|---|---|---|---|
| DTV | 0.4 - 1.0 | 4.0 | 18.0 |
| DTV | 0.4 - 1.0 | 0.9 | 63.0 |
| | | | |
| DVO | 0.4 - 0.7 | 18.0 | 3.5 |
| DVO | 0.4 - 0.7 | 4.0 | 18.0 |
| | | | |
| FLIR | 8.0 - 12.0 | 50.0 | 1.0 |
| FLIR | 8.0 - 12.0 | 10.0 | 5.7 |
| FLIR | 8.0 - 12.0 | 3.1 | 18.0 |
| | | | |
| PNVS | 8.0 - 12.0 | 50.0 | 1.0 |

Table 3.1.4.3-2 RAH-66 Sensor Image Characteristics

| Sensor Mode | Spectral Range (Microns) | Helmet Display FOV (VxH) degs | Magnification |
|---|---|---|---|
| FLIR | 8.0 - 12.0 | 35 x 60 | |
| | | | |
| DTV | | 35 x 60 | |
| | | | |
| LL Intensifier | | 35 x 53 | |

The image generation function shall support ownship speed not less than 300 nm per hour and combined ownship/sensor slew rates of 120 degrees per second. Within this envelop, sensor images shall be free from skipping, popping, data voids and prioritization anomalies.

The image generation function supports rapid switching of sensor modes and FOVs. It shall be possible to generate a complete video image of a new FOV within 0.25 seconds (measured from start of receipt of the first control data word to the start of field display of the new FOV sensor image). Using this same measure, between mode changes shall be accomplished within 0.5 seconds. Mode and FOV switches in one sensor channel shall not have any visible effect in the other sensor or the OTW images.

3.1.4.3.3.3. Transport Delay. The time from the start of transfer of new position and attitude data to the end of display of the video image incorporating these data updates shall not exceed 50 milliseconds and 100 milliseconds for the sensor and OTW images, respectively. These delays assume the best case synchronization between the image generator and the host computer from which the positions and attitude are generated.

3.1.4.3.3.4. Time-of-day. There shall be a minimum of ten (10) selectable daytime and night conditions for each of which the corresponding OTW and sensor images will reflect as appropriate the proper background color, shading, illumination and thermal properties of the displayed materials. Changes to the TOD during a mission shall be supported and shall be accomplished without interruption to the mission.

3.1.4.3.3.5. Atmospheric Fading. The image generation function shall support the simulation of atmospheric attenuation for a continuous range of visibility conditions from zero-visibility (50 meters) in fog conditions to the visibility to support maximum retrieval ranges. It shall be possible to disable all atmospheric fading. The simulated visibility range shall be dynamically selectable to reflect changing atmospheric conditions as well as to avoid the popping of newly activated scene models. It is desirable to have dynamic control over main characteristics of the fading function (e.g., the distances at which fading begins and at which it attains a given percentage of fading toward a target background--black or white).

3.1.4.3.3.6. Color and Sensor Tables. There shall be a sufficient number of different color and sensor tables to support the simultaneous generation of the OTW and two sensor images. There shall also be a sufficient number of such tables and, if required, the capability to dynamically substitute these tables in order to support, for each aircraft type, all potentially displayable sensor types and all TOD conditions.

3.1.4.3.3.7. Texture. It shall be possible to display synthetically-generated and photographically-derived texture patterns on all visible terrain and moving model faces. Color, intensity and transparency modulation shall be supported. The storage of at least one million texels and the addressing of at least 128 texture patterns shall be possible. It shall be possible to have texture patterns at least as large as 256 x 256 texels. It is desirable that multi-colored texture patterns be supported as well as the blending of texture patterns of largely different scale in order to provide continuous texturing over a large dynamic range.

3.1.4.3.3.8. Translucency. There shall be the capability to display translucent faces and there shall be at least 64 levels for translucency ranging from completely opaque to completely transparent. This translucency capability shall be applicable to LOD model transitioning, texturing and in such effects as clouds and smoke. There shall be sufficient frame buffer overwrite capacity to support a translucency overwrite of 80 percent of the image ( the approximate equivalent of 2.0 overwrites per pixel for non z-buffered systems and 4.0 for z-buffered systems). When these capacities are exceeded, the image generator shall manage this overload situation in a non-obtrusive manner). Antialiasing shall apply to texture processing with a quality equivalent to 8 subpixels with uniform weighting.

3.1.4.3.3.9. System Load Control. The Image Generation Function shall provide the load indicators and control mechanisms necessary to support the Visual System Load Control requirements specified for the VSC Function.

3.1.4.3.3.10. Scene Models. Below are given the various types of models which the image generation function shall display. There models shall be displayed to the commanded visibility range for each OTW and sensor image. The maximum visibility ranges shall not less than the following:

a) 10 kilometers for OTW, and
b) 15 kilometers for each sensor.

In order to provide more complex scenes within the capacity of the image generator, multi-level-of-detail representations of models shall be supported along with LOD transitioning using translucency fading.

3.1.4.3.3.10.1. Terrain Model. The image generation function shall support the dynamic retrieval of the terrain data base and shall provide sufficient capacity to store for immediate image generation, along with the active moving and environmental models, a 360 degree region around the ownship which extends to a distance sufficiently beyond the maximum required visibility ranges to allow terrain data loading and deletion without noticeable visible effect, given the maximum allowable ownship speed.

To maximize scene complexity while maintaining the image generation processing load and active data base memory size requirements, the image generation function shall support the use of library models and procedural models such as two-dimensional trees.

3.1.4.3.3.10.2. Moving Models. The image generation function shall support the following types and numbers of moving models which shall be displayed with the proper occulting relationships with respect to the other moving models and the objects in the terrain scene:

a) Ground vehicles with six degrees of freedom of motion and each with one articulated part with at least one degree of freedom of motion: 1000 active within the gaming area with 200 potentially visible in each generated image (i.e., within the maximum visibility range of the ownship).

b) Air vehicles and air weapons (e.g., Hellfire missiles) with six degrees of freedom of motion and two articulated parts each with one degree of freedom of motion each: 16 simultaneously visible in each generated image.

c) Weapon effects, including fire, smoke, bursts and explosions, with at least three degrees of freedom of motion: 40 simultaneously visible in each image (OTW, each sensor). Each of these weapon effects shall be represented as an animated sequence of models; the maximum allowable number of models per sequence shall be no less than 256. Flares are included as weapon effects and shall be modeled as self-illuminated models.

d) Ownship rockets and tracers, with three degrees of freedom and each with a preassigned occulting priority: 35 simultaneously visible in each image.

e) Ownship rotor with at most 3 degrees of freedom of motion: one.

3.1.4.3.3.10.3. Environmental Models. The following environmental effects shall be displayable: Fog and cloud layers, above and below the ownship; horizon band; thunderclouds and lightning.

3.1.4.3.3.10.4 Image Generation Summary. Table 3.1.4.3-2 provides a summary of the requirements for the Image Generation Function. There are some addition details concerning cost, the interface with the VSC and data bases as well as some nonrequired features.

Table 3.1.4.3-2 Summary of IG Specifications
[Continued on next page]

| Summary of IG Specifications | Rev. 1.1 16 August 1991 |
|---|---|
| **Channels** (total of 8) | |
| Out-the-window 6 ea. | RGB Color, 480 x 640 pixel (min.) resolution<br>30 Hz. update rate, 60 Hz. refresh rate<br>70 deg x 135 deg total FOV (6 ea. 35 x 45) |
| Sensor 2 ea. | Monochrome (256 gray shades min.),<br><br>480 x 640 pixel (min.) resolution<br>60 Hz. update and refresh rate |
| **Antialiasing and subpixel occlusion quality** | Equivalent to 8 subpixels w. uniform weighting |
| **Polygon capacity** | 1200 unmeshed flat-shaded textured triangles/channel |
| **Pixel capacity** | 4.0X displayed resolution (z-buffered)<br>2.0 X displayed resolution (non-z-buffered) |
| **Transport delay** | 3.1 update periods (max) |
| **Translucency** | 64 levels (min.) |
| **Texture** | |
| On-line pattern storage | 1 million texels. at least 128 addressable patterns |
| Parameters modulated by texture | Intensity + transparency |
| Pattern sizes (ea. pattern) | 64 x 64, 128 x 128, 256 x 256 texels |
| Antialiasing quality | Equivalent to 8 subpixels w. uniform weighting |
| **Atmospheric haze simulation** | |
| Max visibility, OTW | 10 km. |
| Maximum visibility, sensors | 15 km. |
| Minimum visibility | 50 m. |
| Visibility range | Adjustable 50 m. to 15 km in real time |
| Haze color | White or black |
| **Surface illumination models** | Flat shading, Gouraud shading, self-illuminating |
| **Times-of-day** | 10 selectable (sun angle + ambient) |

| Summary of IG Specifications | Rev. 1.1 16 August 1991 |
|---|---|
| **Moving models (total in 6 OTW channels; ea sensor)** | |
| Aircraft | 16 |
| Weapons effects | 40 special effects + 35 rockets and missiles |
| Ground vehicles | 200 (30 m./sec max speed) |
| **Special effects** | |
| Level-of-detail | 3 levels + null, blended with transparency |
| Animated sequences | up to 256 frames, under real-time control |
| **Dynamic Retrieval** | |
| On-line storage | 500 km x 500 km data base |
| Retrieval range | 15 km (max.) |
| Retrieval rate | To support ownship speed up to 300 Kts. |
| Turn rates | To support 120 deg./sec ownship turn rate |
| **Controller Interface** | Provide DMA interface to IG with a compatible 9U VME card for the Visual System controller |
| **Modeling system/ database compatibility** | IG must be compatible with Software Systems, Inc., Multigen product. Translators may be provided to convert Multigen "Flight" format to the IG. |
| **Cost** | $1020 K, recurring per IG |
| **Demonstration Data Base** | One 10 km x 10 km database in the Hunter-Liggett area suitable for demonstrating IG functionality and features. |
| **Other features** | |
| Sensor effects post-processing | Not Required |
| Light points | Not Required |
| Crash detection | Not Required (Feature is provided elsewhere) |
| Line-of-sight testing | Not Required (Feature is provided elsewhere) |
| Landing lights/spot lights | Not Required |
| Vehicle ground tracks | Not Required |

Table 3.1.4.3-2 Summary of IG Specifications
[Continued]

**Notes on the Image Generator Specification Summary**

**Channels** : Resolution higher than 640 x 480, preferably as close to 1280 x 1024 as possible, is one of the most desired enhancements over the minimum specifications. An area-of-interest display system may be proposed to achieve equivalent high resolution. Approaches providing higher resolution for targets are also acceptable. The cost target for image generator (IG) plus displays, not including the helmet displays and cockpit multi-function displays is $1250K. Sensors channels may be each be driven from a single color of a conventional RGB (red-green-blue) channel. The two sensor eyepoints may be different from the nominal visual eyepoints and may change as different sensors are selected for display on each of the two channels.

**Antialiasing** : If the antialiasing and subpixel occlusion methods provide less quality than the equivalent of eight subpixels under certain circumstances, those circumstances are to be described by the IG vendor. Examples of potentially troublesome circumstances are edges viewed through a partially transparent object, vertices having a large number of adjoining polygons, lines of interpenetration, and small polygon entirely within a pixel.

**Polygon capacity** : Polygon capacities slightly lower than the nominal specified may be proposed, and may be acceptable if there is a substantial cost saving or if other features of high value, such as enhanced texture or high resolution, are included.

**Pixel capacity**: We presume that all polygon-based IG system must generate more pixel values than are ultimately displayed. Extra pixels are needed so that two or more pixel values may contribute to an antialiased pixel containing an edge or vertex, and extra pixels are need to provide translucent surfaces for model switching and special effects. The requirement for 100% extra pixel capacity may be waived if an innovative approach is proposed to avoid the potential limitations of pixel capacity. Z-buffered system conventionally also generate pixels which are ultimately occluded before display, thereby requiring much higher overwrite capacity.

**Texture**: Texture must be perspectively correct and free from distracting artifacts of an kind. It must appear to be "stuck" to the textured surface as the viewpoint changes with respect to the surface.

**Moving Models**: Aircraft models must be correctly occluded at all times. Ownship weapons effects may use approximate occlusion techniques if a rationale of acceptability is given. The entire simulation scenario may include up to 2000 tanks or other ground vehicles, up to 200 of which may be in view at any one time. Occlusion of ground vehicles may be in error for up to 1/15 second when the occlusion geometry changes; although it is preferable that no errors occur.

**Dynamic Retrieval**: At least 1 GByte of writable disc storage must be included with the IG, and a means for downloading data bases off-line, through the visual system controller interface, must be provided. The disc storage must have sufficient capacity to contain the entire data base required for any given mission.

**Controller Interface**: If five 9U VME slots are provided in a VME backplane within the IG for the purpose of housing the Visual System Controller, than the IG interface may be accomplished directly over the VME backplane instead of by external DMA. If the Controller is separately housed, a receiving 9U VME card must be provided capable of driving up to 12 feet of interconnecting cable.

**Modeling System**: The intent is to use Multigen for database editing and to use the Multigen Flight format for commonality, as many existing data bases may easily be translated into the flight format. Note that a modeling system is not bundled with the procurement of the image generator.

**Cost:** The cost target for the IG plus OTW displays and helmet displays is $1370 K. Tradeoffs may be made among these elements to provide a system solution, if desired. Alternatives providing cost and performance trades roughly over the range of +50% and -30% of the nominal cost are encouraged.

**Demonstration data base:** The purpose of the demonstration data base is solely to facilitate system integration and acceptance of the image generator. It must be Multigen compatible, include data for at least one animated sequence, include at least one moving model type, and at least one model switching sequence to show the level-of-detail capability.

3.1.4.4. Display Device Function.

3.1.4.4.1. Purpose. The role of the Display Device Function is to display to the two crew members the OTW video image generated by the Image Generation Function and to display the sensor images which are intended for helmet display. The video for the OTW scene (six channels of video are proposed) is produced by the Image Generation Function and routed directly to the OTW display device. The video for the two sensor images is first routed from the Image Generation Function to the Flight Station Module which adds the necessary symbology and either returns the merged video to the Display Device Function for display in one or both crew member helmets and/or is retained by the Flight Station Module for display in one or several multifunction displays in the cockpit.

3.1.4.4.2. Physical Characteristics. The Display Device Function shall have two types of display systems for each ARWA device: The OTW display system and the helmet-mounted display system. All cockpit arrangements ( the tandem AH-64D and RAH-66 cockpits) shall use the same OTW display device and helmet displays.

There shall be two helmet display systems for an ARWA device. Each helmet display shall be able to provide the simulation of the AH-64D monocle of Integrated Helmet and Display Sight System (IHADSS) and the RAH-66 binocular display of the Helmet Integrated Display Sight System (HIDSS).

The OTW display system shall support the different cockpit configurations such that any reconfiguration required of the OTW display system to accommodate a cockpit change shall be accomplished within the required reconfiguration time (Refer to Volume I, Paragraph 3.1.4).

The size of the OTW display system shall be such that a single ARWA device is able to have a footprint not exceeding the 16 foot by 16 foot area requirement.

3.1.4.4.3. Performance Characteristics. Below are given the main performance characteristics which must be provided by the Visual Module Display Device Function. When appropriate, the OTW and helmet sensor display characteristics are discussed separately in each of the following paragraphs.

3.1.4.4.3.1. Field Of View. In each of the different types of cockpit configurations, the OTW display device shall support the FOV requirements of the Image Generation Function from an eyepoint position midway between the nominal head position of the two crew members. The displayed field of view may be static in relationship to the ownship orientation.

The helmet display shall be able to support a 30 degree by 40 degree FOV in the monocular mode and a 40 degree by 60 degree FOV in the binocular mode.

3.1.4.4.3.2. Resolution. The resolution of the OTW display device shall be such that the combined resolution capability of the display device coupled with the image generator are not less than the resolution provided by Image Generation Function for the OTW image or eight (8) arc minutes per optical line pair, whichever requirement is the less restrictive.

Similarly, for the helmet display, the combined resolution capability shall not be less than the minimum resolution provided by Image Generation Function for the sensor images or eight (8) arc minutes per optical line pair, whichever requirement is the less restrictive.

3.1.4.4.3.3. Luminance. The OTW display device shall provide a minimum of 6 foot-lamberts as measured from the nominal eyepoint the center of each channel. The luminance mismatch between channels shall be less than 5%.

The analogous luminance requirements shall apply to the monocular and binocular helmet displays.

3.1.4.4.3.4. Contrast Ratio. Both the OTW and the helmet displays shall provide at least a 15:1 contrast ratio (measured using a checkerboard pattern).

3.1.4.4.3.5. Color Convergence. The OTW display devices shall have color convergence errors of less than 0.2% of channel picture height. Apparent discrepancies between the color display of different channels shall be correctable without the replacement of system hardware.

3.1.4.4.3.6. Geometric Distortion. For each channel of the OTW display the maximum geometric distortion, from the perspective of the nominal eyepoint, shall be less than 2% of the channel picture height. Geometric edge matching errors between adjacent channels shall be less than 0.5% of picture height.

For the helmet display device, the maximum geometric distortion shall be 2% of picture height. There shall be no observable artifacts due to the overlapping of the two binocular views.

There will be some geometric distortion due, not to the display device itself, but to the displacement of the crew members' viewpoints from the single eyepoint from which the OTW images are generated.

This discrepancy between different viewing positions of the two crew members and the image eyepoint also results in different look-angles to the same display object for the two crew members. While the above two types of geometric distortion are not considered detrimental to the ARWA mission goals, proposals for visual system should address methods by which they can be minimized.

3.1.4.5. Intervisibility Function.

3.1.4.5.1. Purpose. The Intervisibility Function provides, for both the Visual Module and the other modules of the ARWA device, various computational services to determine the relationships between selected models and positions in the data base (occulting relationships, distances, penetrations) or between positions of a model or eyepoint at two different times (extrapolation) or between one position and orientation in different coordinate systems (coordinate transformations).

3.1.4.5.2. Physical Characteristics. There are several possible physical realizations of the system providing the computational environment for the Intervisibility Function.

The proposed realization (Refer to the ADST Step One Technical Report, Section 4.0) is a stand-alone computation system which includes a data base representation of the terrain and moving models. This computational system is linked to the Visual System Controller via and FDDI bus and can therefore be potentially shared by the other ARWA devices and all future semi-automated forces (SAFOR) devices.

Other realizations include the Intervisibility Function being shared between the visual system controller and the image generator or being shared between the visual system controller, the image generator and a separate computational system which performs only a portion of the Intervisibility Function.

3.1.4.5.3. Performance Characteristics. The Intervisibility Function shall provide the types of computations described in the paragraphs below. With each computational type, there is an indication of the data required for the computation, the product of the computation and a specification of how many such computations (tests) are required per second. For all test types discussed below, it shall be possible to exclude data models by data base type (e.g., exclude all tree models).

3.1.4.5.3.1. Occulting Determination. For this test type, two positions in data base coordinates are given and the test computation determines whether the line segment (or volume centered around the line segment) intersects some data base model. Occulting determination tests are used:

a) To decide which threats are visible to the ownship for possible display and/or possible inclusion on a tactical map.

b) To determine whether the ownship is occulted from radars, electronic warfare (EW) sensors and communication devices.

c) (For SAFOR use) To determine for each threat when it can detect and/or engage the ownship.

d) To support the assignment of occulting relationships among all moving models in the event that a non z-buffered image generator requires support from the VSC Function.

The Intervisibility Function shall support (for each ARWA device) a minimum of 500 occulting determination tests per second of an average length of one-half the maximum visibility range. With the introduction of SAFOR, the Intervisibility Function shall support an additional 5000 occulting test per second of an average length of one-half the maximum visibility range.

3.1.4.5.3.2. Distance Determination. This type of intervisibility test requires a starting position and either an ending position or direction. The test returns a distance to the closest data base model from the starting position along the ray toward the ending position or in the given direction. Also returned with the distance is a model type descriptor. This distance determination test can be used:

a) To simulate the ownship laser range finding capability.

b) To determine height above terrain of above other objects in order to simulate the radar altimeter function and to simulate landings (height above ground of the landing gears).

c) To determine ownship weapon impact points for weapon scoring.

The Intervisibility Function shall support (for each ARWA device) a minimum of 120 distance determinations per second of an average length of one-half the maximum visibility range.

3.1.4.5.3.3. Volume Penetration Determination. This Intervisibility Function test is given a position and orientation of a volume (e.g., as enclosed by six planes) and the test returns an indication of whether there is a penetration of this volume by any data base models. The volume penetration test can be used:

a) To determine ownship hard and soft (tree branches) crashes.

b) To decide when a moving threat has penetrated a nondisplayable shadow volume of another model and thus should be given reduced visibility from the ownship.

c) To allow SAFOR moving models to avoid data base models.

The Intervisibility Function shall support (for each ARWA device) a minimum of 30 volume penetration tests per second. SAFOR will require 500 volume penetration test per second.

3.1.4.5.3.4. Ground Vehicle Placement. This is the capability to determine the correct position and attitude of a ground vehicle for placement on a terrain face based on the projected position on the XY plane. This determination would involve the use of a height-above-terrain type test for the first appearance of a vehicle on a terrain face. Additional position and attitudes for the same face are directly derivable from those of the first appearance.

This type of ground placement is required to keep on (not above or below) the surface of the terrain vehicles which have been positioned by non-ARWA systems. These systems may use geometrically different models of the terrain and will provide outdated position data due to transport delays. Any system (e.g.,SAFOR) which controls the movement of ground vehicles will require this capability.

Each ARWA device requires a minimum of 1000 vehicle placement test per second.

3.1.4.5.3.5. Extrapolation and Coordinate Conversion. If the Intervisibility Function is a resource shared between several ARWA devices, redundant conversions of position and attitude data to the coordinate systems used in the ARWA devices can be eliminated. If, in addition, the ARWA devices are synchronized, redundant extrapolation computations can also be eliminated.

3.1.4.6. Helmet Tracker Function.

3.1.4.6.1. Purpose. The Helmet Tracker Function provides to the VSC Function the position and attitude, relative to the cockpit, of helmet of each crew member. These data are used by the VSC Function to compute the field of view for the generation of the sensor images.

3.1.4.6.2. Physical Characteristics. The device or devices (there will most likely be two) shall not obstruct the crew members view of the cockpit or the OTW display and shall be capable of a physical interface with the VSC in a manner which adds less than one millisecond delay.

3.1.4.6.3. Performance Characteristics. The Helmet Tracker Function shall provide the VSC Function with helmet positions and attitudes for the two crew members at a rate of 60 Hz. There shall be less than an eight (8) millisecond delay from the time the positional data was obtained to the time they are available to the VSC. The accuracy of the positional data generated by the Head Tracker Function shall be such that there is no noticeable irregularities in the resulting sensor image. The function shall be able to provide accurate positional information for all helmet position and attitudes encountered during mission simulation. The Helmet Tracking Function shall support all aspects of Visual Module diagnostics as described in Paragraphs 3.1.3 and for the VSC Function..

3.1.4.7. Data Base Storage Function.

3.1.4.7.1. Purpose. The purpose of this function is to store for retrieval during Simulation Mode the terrain and other data base mods in support of the current mission.

3.1.4.7.2. Physical Characteristics. The physical medium for data base storage shall be removable to obviate the need to clean the medium of secure data during Shut Down Mode.

The Data Base Storage Function shall be able to provide storage of the entire data base required for a mission. This shall include the 500 km by 500 km gaming area and all moving and environmental models. It shall be possible to update the stored data base with data base revisions and/or new data base to support new missions.

The Data Base Storage Function shall allow retrieval rates specified for the VSC Function.

This function shall support the equipment test and morning readiness diagnostics described in Paragraph 3.1.3.

3.1.4.7.3. Performance Characteristics. Refer to Data Base Storage Function, Physical Characteristics.

3.1.5. Module Functional Relationships. Figure 3.1.4-1 provides a top-level view of the interrelationship of the various functions of the Visual module. The control and data exchange among these functions is described in the relevant sections of Paragraph 3.1.4.

3.1.6. Configuration Allocation. In addition to the requirements contained in Volume I of this specification, Paragraph 3.1.6, the Visual Module has additional requirements which are given in this paragraph. The Visual Module shall be comprised of one Computer Software Configuration Item (CSCI) and seven (7) Hardware Configuration Items (HWCI). The allocation of these configuration items is as follows:

a) CSCI #1: Visual System Controller Function Software

b) HWCI #1: ARWA Global Bus Interface Function Hardware

c) HWCI #2: Visual System Controller Function Hardware

d) HWCI #3: Image Generation Function Hardware

e) HWCI #4: Display Device Function Hardware

f) HWCI #5: Intervisibility Function Hardware

g) HWCI #6: Helmet Tracker Function Hardware

h) HWCI #7: Data Base Storage Function Hardware

3.1.7. Interface Requirements. The various internal and external interfaces are illustrated in Figure 3.1.4-1.

3.1.7.1. External Interfaces. The external interfaces for the Visual Module shall consist of the following:

a) ARWA Global Bus Interface. This is the interface of the Visual Module with the other modules in the ARWA device. The ARWA Global bus interface requirements are given in Volume I of this specification, Paragraph 3.1.7 and the ARWA SSM IDD, Appendix A.

This interface also provides the interface of the Visual Module with the Simulation Manager including the program files of the Software Maintenance Station and the data base files of the Data Base Maintenance Station. In addition, when the Visual Module is in the stand-alone state of Module Mode, any workstation connected to the network can act as a control console for the stand-alone operations. The commands and data required in stand-alone state are given in the paragraph concerning the stand-alone operations of the VSC Function, Section 3.1.4.

This interface shall also logically support the communications between the Intervisibility Function and the intervisibility control of the VSC Function. A description of the contents of the communications between these two functions is given in the paragraph concerning the Intervisibility Function in 3.1.4 of this specification. In addition, during the alignment state of Simulation Mode, the Visual Module can transfer data base files from the Data Base Maintenance Station and the data base storage of the Visual Module.

b) Flight Station Interface. The Visual Module produces up to two channels of video imagery which is routed to the Flight Station Module. Symbology is then merged with these video outputs and they are then routed by the Flight Station Module for display in the MFDs of the cockpit and/or in one or both helmet displays.

3.1.7.2. Internal Interfaces. Figure 3.1.4-1 provides a top-level view of the interfaces of the various components of the Visual module. The physical nature of these interfaces and the logical contents of the communication between these component are described in the relevant paragraphs of Paragraph 3.1.4 of this specification.

3.1.8. Government Furnished Property. The following is the government furnished property required by the Visual Module in addition that specified in Paragraph 3.1.8 of Volume I of this specification:

3.2. System Characteristics. The system characteristic requirements for the Visual Module shall be as specified in Paragraph 3.2 of Volume I of this specification.

3.3. Visual Module Processing Resources. The System Processing Resources requirements of Paragraph 3.3 of Volume I of this specification shall all to the processing resources of the Visual Module.

3.4. Quality Factors. The requirements of Paragraph 3.4 of Volume I of this specification shall apply.

3.4.1. Reliability. The requirements of Paragraph 3.4 1 of Volume I of this specification shall apply.

3.4.2. Maintainability. The requirements of Paragraph 3.4 2 of Volume I of this specification shall apply.

3.4.3. Flexibility and Expansion. The requirements of Paragraph 3.4 3 of Volume I of this specification shall apply.

3.4.4. Availability. The requirements of Paragraph 3.4 4 of Volume I of this specification shall apply.

3.4.5. Portability. The requirements of Paragraph 3.4 5 of Volume I of this specification shall apply.

3.5. Logistics. The logistics requirements specified in Paragraph 3.5 of Volume I of this specification shall apply to the Visual Module.

3.6. Precedence. The precedence requirements specified in Paragraph 3.6 of Volume I of this specification shall apply to the Visual Module.

4. VERIFICATION REQUIREMENTS

4.1 General. The system level general verification events, levels and methods of testing for the Visual System module are defined in Volume I of this specification, paragraph 4.1 and all subparagraphs of paragraph 4.1. For the Visual System module operating in the ARWA SS, there are no additional general verification requirements.

4.1.1 Philosophy of Testing. In addition to the testing philosophy identified in Volume I of this specification, paragraph 4.1.1, informal standalone module testing shall be conducted for the flight station module prior to integration with the system. The intent of these tests shall be to identify and resolve any unique module related deficiencies prior to system integration thus reducing integration problems.

4.1.1.1 Testing Events. Scheduled testing shall take place sequentially in the following phases.

4.1.1.1.1 Verification Test. Verification test at a system level shall be conducted as specified in Volume I of this specification, paragraph 4.1.1.1.1. Module level verification testing shall be accomplished prior to shipment of the module to the integration facility and shall ensure that the module meets the functional and performance requirements of this volume of the specification.

4.1.1.1.2 Acceptance Test. Acceptance test at a system level shall be conducted as specified in Volume I of this specification, paragraph 4.1.1.1.2. Module level acceptance testing shall consist of installation and checkout of the module at the integration facility and accomplishment of a subset of the module level verification tests to ensure that the module meets the functional and performance requirements of this volume of the specification in the installed configuration.

4.1.2 Location of Testing. All system level testing shall be accomplished in the locations identified in Volume I of this specification, paragraph 4.1.2. All module level verification testing shall be accomplished at the module builders facility. All module level acceptance testing shall be accomplished at the system integration facility.

4.1.3 Responsibility for Tests. The responsibility for system level testing shall be as defined in Volume I of this specification, paragraph 4.1.3. The responsibility for module level testing shall be allocated to the module builder and system integrator.

4.1.4 Verification Methods. Verification methods shall be as defined in Volume I of this specification, paragraph 4.1.4.

4.2 Formal Tests. Formal test shall consist of functional and performance testing.

4.2.1 Performance Evaluation. Performance evaluations which verify the design and development of the configuration items shall be performed to test that the design and performance of the configuration items meet the requirements specified in paragraph 3.1 of this Volume and Volume I of this specification. Performance evaluation shall consist of inspections, analyses, demonstrations and tests.

4.2.3 Reliability and Maintainability. Reliability and maintainability testing shall not be performed.

4.2.4 Test Equipment. Test equipment requirements applicable to all modules are described in Volume I of this specification, paragraph 4.2.4. There is no additional module unique test equipment required to verify that the configuration items and assembled module meet the requirements specified in paragraph 3, Requirements, of this Volume and Volume I of this specification.

4.3 Formal Test Constraints. The formal test constraints for the ARWA SS system are described in Volume I of this specification, paragraph 4.3. There are no additional formal test constraints unique to the Visual System module.

4.4 Verification Cross Reference. Table 1, Visual System Verification Cross Reference Matrix, provides a requirements/verification cross reference guide for the Visual System module using the definitions provided in Volume I of this specification, paragraph 4.1.4.

| Legend: NA-Not Applicable I-Inspection D-Demonstration A-Analysis T-Test | | | | | | |
|---|---|---|---|---|---|---|
| Section 3 Requirements Reference | Qualification Method(s) | | | | | Section 4 Qualification Requirement Reference |
| | NA | I | A | D | T | |
| 3. | NA | | | | | |
| 3.1 | NA | | | | | |
| 3.1.1 | | | | D | | 4.2.1 |
| 3.1.2 | NA | | | | | |
| 3.1.3 | | | | D | | 4.2.1 |
| 3.1.3.1 | | | | D | | 4.2.1 |
| 3.1.3.1.1 | | | | D | | 4.2.1 |
| 3.1.3.1.2 | | | | D | | 4.2.1 |
| 3.1.3.2 | | | | D | | 4.2.1 |
| 3.1.3.3 | | | | D | | 4.2.1 |
| 3.1.3.3.1 | | | | D | | 4.2.1 |
| 3.1.3.3.2 | | | | D | | 4.2.1 |
| 3.1.3.3.3 | | | | D | | 4.2.1 |
| 3.1.3.3.4 | | | | D | | 4.2.1 |
| 3.1.3.4 | | | | D | | 4.2.1 |
| 3.1.3.5 | | | | D | | 4.2.1 |
| 3.1.4 | | | | D | | 4.2.1 |
| 3.1.4.1 | NA | | | | | |
| 3.1.4.1.1 | NA | | | | | |
| 3.1.4.1.2 | NA | | | | | |
| 3.1.4.1.3 | | | | D | | 4.2.1 |
| 3.1.4.2 | NA | | | | | |
| 3.1.4.2.1 | NA | | | | | |
| 3.1.4.2.2 | NA | | | | | |
| 3.1.4.2.3 | NA | | | | | |
| 3.1.4.2.3.1 | | | | D | | 4.2.1 |
| 3.1.4.2.3.2 | | | | D | | 4.2.1 |
| 3.1.4.2.3.3 | | | | D | | 4.2.1 |
| 3.1.4.2.3.4 | | | | D | | 4.2.1 |
| 3.1.4.2.3.5 | | | | D | | 4.2.1 |
| 3.1.4.2.3.6 | | | | D | | 4.2.1 |
| 3.1.4.2.3.7 | | | | D | | 4.2.1 |
| 3.1.4.2.3.8 | | | | D | | 4.2.1 |
| 3.1.4.2.3.9 | | | | D | | 4.2.1 |
| 3.1.4.2.3.9.1 | | | | D | | 4.2.1 |
| 3.1.4.2.3.9.2 | | | | D | | 4.2.1 |
| 3.1.4.2.3.9.3 | | | | D | | 4.2.1 |
| 3.1.4.2.3.10 | | | | D | | 4.2.1 |
| 3.1.4.2.3.11 | | | | D | | 4.2.1 |
| 3.1.4.2.3.12 | | | | D | | 4.2.1 |
| 3.1.4.3 | NA | | | | | |
| 3.1.4.3.1 | NA | | | | | |
| 3.1.4.3.2 | NA | | | | | |

Table 4. Visual System Module Verification Cross Reference Matrix
[Continued on next page]

| Legend: NA-Not Applicable I-Inspection D-Demonstration A-Analysis T-Test | | | | | | |
|---|---|---|---|---|---|---|
| Section 3 Requirements Reference | Qualification Method(s) | | | | | Section 4 Qualification Requirement Reference |
| | NA | I | A | D | T | |
| 3.1.4.3.3 | NA | | | | | |
| 3.1.4.3.3.1 | | | | D | | 4.2.1 |
| 3.1.4.3.3.2 | | | | D | | 4.2.1 |
| 3.1.4.3.3.3 | | | | D | | 4.2.1 |
| 3.1.4.3.3.4 | | | | D | | 4.2.1 |
| 3.1.4.3.3.5 | | | | D | | 4.2.1 |
| 3.1.4.3.3.6 | | | | D | | 4.2.1 |
| 3.1.4.3.3.7 | | | | D | | 4.2.1 |
| 3.1.4.3.3.8 | | | | D | | 4.2.1 |
| 3.1.4.3.3.9 | | | | D | | 4.2.1 |
| 3.1.4.3.3.10 | | | | D | | 4.2.1 |
| 3.1.4.3.3.10.1 | | | | D | | 4.2.1 |
| 3.1.4.3.3.10.2 | | | | D | | 4.2.1 |
| 3.1.4.3.3.10.3 | | | | D | | 4.2.1 |
| 3.1.4.3.3.10.4 | | | | D | | 4.2.1 |
| 3.1.4.4 | NA | | | | | |
| 3.1.4.4.1 | NA | | | | | |
| 3.1.4.4.2 | NA | | | | | |
| 3.1.4.4.3 | NA | | | | | |
| 3.1.4.4.3.1 | | | | D | | 4.2.1 |
| 3.1.4.4.3.2 | | | | D | | 4.2.1 |
| 3.1.4.4.3.3 | | | | D | | 4.2.1 |
| 3.1.4.4.3.4 | | | | D | | 4.2.1 |
| 3.1.4.4.3.5 | | | | D | | 4.2.1 |
| 3.1.4.4.3.6 | | | | D | | 4.2.1 |
| 3.1.4.5 | NA | | | | | |
| 3.1.4.5.1 | NA | | | | | |
| 3.1.4.5.2 | NA | | | | | |
| 3.1.4.5.3 | NA | | | | | |
| 3.1.4.5.3.1 | | | | D | | 4.2.1 |
| 3.1.4.5.3.2 | | | | D | | 4.2.1 |
| 3.1.4.5.3.3 | | | | D | | 4.2.1 |
| 3.1.4.5.3.4 | | | | D | | 4.2.1 |
| 3.1.4.5.3.5 | | | | D | | 4.2.1 |
| 3.1.4.6 | NA | | | | | |
| 3.1.4.6.1 | NA | | | | | |
| 3.1.4.6.2 | NA | | | | | |
| 3.1.4.6.3 | | | | D | | 4.2.1 |
| 3.1.4.7 | NA | | | | | |
| 3.1.4.7.1 | NA | | | | | |
| 3.1.4.7.2 | NA | | | | | |
| 3.1.4.7.3 | | | | D | | 4.2.1 |
| 3.1.5 | | | | D | | 4.2.1 |

Table 4. Visual System Module Verification Cross Reference Matrix
[Continued]

| Legend: NA-Not Applicable I-Inspection D-Demonstration A-Analysis T-Test | | | | | | |
|---|---|---|---|---|---|---|
| Section 3 Requirements Reference | Qualification Method(s) | | | | | Section 4 Qualification Requirement Reference |
| | NA | I | A | D | T | |
| 3.1.6 | | I | | | | 4.2.1 |
| 3.1.7 | NA | | | | | |
| 3.1.7.1 | | | | D | | 4.2.1 |
| 3.1.7.2 | | I | | | | 4.2.1 |
| 3.1.8 | | I | | | | 4.2.1 |
| 3.2 | | I | | | | 4.2.1 |
| 3.3 | | I | | D | | 4.2.1 |
| 3.4 | NA | | | | | |
| 3.4.1 | | | | D | | 4.2.1 |
| 3.4.2 | | | | D | | 4.2.1 |
| 3.4.3 | | | | D | | 4.2.1 |
| 3.4.4 | | | | D | | 4.2.1 |
| 3.4.5 | | | | D | | 4.2.1 |
| 3.5 | | | | D | | 4.2.1 |
| 3.6 | | | A | | | 4.2.1 |

Table 4. Visual System Module Verification Cross Reference Matrix [Continued]

## 5. PREPARATION FOR DELIVERY

The preparation for delivery requirements for the ARWA SS are specified in Volume I of this specification, paragraph 5. There are no additional or specific preparation for delivery requirements applicable to the Visual System module.

## 6. NOTES

### 6.1. Acronyms.

| | |
|---|---|
| ADST | Advanced Distributed Simulation Technology |
| ANVIS | Airborne Night Vision System |
| ARWA | Advanced Rotary Wing Aircraft |
| BIU | Bus Interface Unit |
| CSCI | Computer Software Configuration Item |
| CDRL | Contract Data Requirement List |
| DoD | Department of Defense |
| DTV | Direct Thermal Viewer |
| DVO | Direct View Optics |
| EW | Electronic Warfare |
| FDDI | Fiber-Distributed Data Interface |

| | |
|---|---|
| FLIR | Foward-Looking Infrared |
| FOV | Field of View |
| H | horizontal |
| HIDSS | Helmet Integrated Display Sight System |
| HWCI | Hardware Configuration Item |
| IG | Image Generator |
| IHADS | Integrated Helmet and Display Sight System |
| LOD | level-of-detail |
| MFD | Multifunction Display |
| ModSim | Modular Simulator |
| NVG | Night Vision Goggles |
| OTW | Out-the-window |
| PNVS | Pilot's Night Vision System |
| ROM | read-only memory |
| SAFOR | Semi-automated Forces |
| TBD | To Be Determined |
| TIS | Thermal Imaging Sensor |
| TOD | Time-of-day |
| V | Vertical |
| VSC | Visual System Controller |